METHOD FOR MANUFACTURING A SPLIT PROBE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method for manufacturing split probes used as probes and nano-forceps used in scanning of semiconductors.

2. Description of Related Art

A method for manufacturing micro-forceps using a focused ion beam device on the tip of a probe of a microcantilever used as a probe microscope probe has recently drawn attention (refer to patent document 1).

A split probe of the related art is shown in FIG. 5. FIG. 5(a) is a side view of a microcantilever, where numeral 8 is a cantilever probe. FIG. 5(b) is the upper surface of the microcantilever. FIG. 5(c) is an enlarged view of portion 7 of FIG. 5(b). In a typical method taken as a specific procedure for manufacturing microforceps, the whole of a probe 8 is irradiated with a beam that has been finely focused by a focused ion beam device without tilting a sample, an image for the whole of the scanned probe 8 is obtained, and a processing position is decided. A process of forming a channel 9 by making insulating locations on the cantilever that are to be severed face the beam from a center part of the tip of the probe on the microcantilever and then irradiating and scanning just a specific two locations is then carried out. The tip of the probe 8 is then split into a two-electrode structure where each electrode is electrically conductive.

"Patent Document 1"

Japanese Patent Laid-open Publication No. 2001-252900 ([0048], FIG. 10, FIG. 11).

However, in the related processing method, 1) The radius of curvature of the cantilever probe tip is small at 100nm or less. It is therefore difficult to determine the central part of the cantilever probe tip in methods for specifying processing position using an image for the whole tip taken from above, and splitting the true center into two is therefore difficult. 2) Because the whole of the probe is processed using the same focused ion beam current, a relatively large focused ion beam current is used in the processing, and the channel processing width therefore becomes large. A large processing channel means that the distance between the divided electrodes is large, and it is difficult to obtain the desired electrode pitch when using the split probe as microscopic electrodes as is. Further, for example, during the assembly of, for example, carbon nanotubes, gaps open up between fellow carbon nanotubes so that, for example, a voltage applied during electrostatic driving has to be made high. 3) When an extremely narrow range of a cantilever probe is irradiated and scanned in order to decide processing position using the focused ion beam current amount using 2), the etching speed is fast because the ion beam current is large. This causes damage to the tip of the probe of the cantilever greater than that which is tolerated, so as to bring about problems such as, for example, localized peeling of conductive coats and non-uniformity of electric field, and localized increases in electrical resistance.

SUMMARY OF THE INVENTION

In order to resolve the aforementioned problems, the current application sets out to provide a simple method for manufacturing a more finely detailed split probe with less damage being incurred.

In order to resolve the problems described above, the following method is used in a method for manufacturing a split probe of the present invention.

1. A method is provided for easily deciding a processing position by making it easy to determine the center of a probe tip by tilting the whole of a microcantilever.

2. A method for processing channels is provided employing a small focused ion beam current in processing of an extremely narrow range of a probe tip of a microcantilever and employing a focused ion beam current larger than the aforementioned processing current in processing of a broader range.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing a SIM image of a probe tip with the probe tip inclined.

FIG. 2 is a schematic view showing a SIM image of a probe tip after channel processing with the probe tip inclined.

FIG. 3 is a top view of a probe portion of a microcantilever after channel processing.

FIG. 4 is a SIM image of channels 1, 2 and 3 formed in a probe of a microcantilever.

FIGS. 5A-5C are schematic views of a conventional split probe provided on a microcantilever.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following is a description of embodiments of this invention using the drawings. In the drawings, the relationship of the size, shape and arrangement of each structural component is shown in outline to an extent that this invention may be understood and numerical conditions given in the following description are merely given as an illustration.

A first embodiment of the present invention is now described with reference to the drawings.

FIG. 1 is a view showing a focused and scanned ion beam current of 1pA is irradiated only on the very tip of the cantilever with the whole of a cantilever inclined at an angle of sixty degrees to the longitudinal direction taking the horizontal as 0 degrees. Secondary charged particles emitted at the time of irradiation with the ion beam are detected, and an SIM image is obtained when a secondary particle signal intensity is displayed on a CRT in synchronism with the scanning signal. A SIM image for the probe tip is shown in FIG. 1. Next, after processing position deciding is carried out from the SIM image of FIG. 1, processing for a channel 1 is carried out using the same focused ion beam current as for the irradiation and scanning in FIG. 1 in order to divide the probe tip into two. The channel 1 is shown in FIG. 2. Processing is not carried out through 180 degrees to the opposite side of the probe tip because the ion beam current is low. Because of this, the inclination of the entire cantilever is left as is, and a channel 2 is processed using the same method as for channel 1 at the opposite section of the probe after rotation through 180 degrees on an axis vertical to the microcantilever, so that the channel 1 and the channel 2 are connected together. In fact, since the microcantilever is disposed on the sample stage , the sample stage is rotated 180 degrees so as to rotate the microcantilever after carrying out processing for the first channel, and with the direction maintained the probe tip is positioned under the focused ion beam and scanned and grooved by the focused ion beam to form channel 2. When forming channel 2, the sample stage is rotated 180 degrees in the above process. But it is available to scan the focused ion beam at the tip

center of the prove after positioning it under the focused ion beam after returning the sample stage to the horizontal position. After carrying out processing for the first and second channels, processing is carried out to make a channel connecting these channels. This is shown in FIG. 3. In FIG. 3, numeral 10 is a wiring pattern formed on the cantilever substrate surface, and numeral 11 is a conductive film formed on the cantilever substrate surface and probe connecting with the wiring pattern 10. In FIG. 3, after the whole of the cantilever 6 is returned to a horizontal state, the channel 3 is formed radially at two locations from the point of intersection of the channels 1 and 2. The conductive film 11 is divided by the channel 3. The processing of the channel 3 is carried out using a focused ion beam current of 50pA. After processing channel 1 and channel 2, by processing the channel 3, the probe tip is electrically divided into two items and conductivity is lost, so as to finally give a two electrode structure. FIG. 4 shows processing channels 1, 2 and 3 formed in a probe of a microcantilever using the method of the present invention as an SIM image. Channels of processing widths of 10 to 500nm can be formed at the central position of the probe tip.

A focused ion beam is used in processing of the channel but finer processing is possible if an electron beam etc. is used. In this embodiment, an example of processing a probe on a microcantilever is shown, but this method may also be similarly applied to processing of a probe arranged on, for example, a membrane. The present invention is also effective for a cone, triangular pyramid, or polygonal pyramid having a pinnacle with a radius of curvature of 100nm or less.

The split probe is such that a single terminal (for example,

a carbon nanotube) may be fitted to the split probe itself or to each terminal, and may be used as nano-forceps.

This may then be used as a semiconductor scanning probe or a probe card by arranging a plurality of cantilever beams having the split probes or arranging a plurality of the split probes on the surface of the same probe card.

As described in detail above, according to this invention, the following effects are obtained by channel processing the split-probe tip in a split-tip manufacturing process.

The entire structure itself is tilted, and probe tip processing is carried out. It is therefore easy to determine the central part of the probe tip. Further, a small focused ion beam current is employed. It is therefore possible to make two electrodes with a minimum channel processing width, and there is little damage to the processing portion. Further, in the probe tip channel processing, processing takes place with a small focused ion beam current, and in channel processing in order to divide the electrodes connected to these channels, processing is carried out using a large focused ion beam current, and throughput can therefore be increased.

Moreover, this is formed with a smaller channel processing width. Clenching precision of the forceps can therefore be improved.